Monitoring by Delegates or by Peers?
Joint Liability Loans under Moral Hazard

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Abstract

This paper analyzes the conditions under which joint liability loans to encourage peer-monitoring would be offered and chosen ahead of monitored individual liability alternatives on a competitive loan market when production and monitoring activities are subject to moral hazard. In contrast to other analyses, the case for joint liability loans does not rest on an assumed monitoring or information advantage by borrowers but instead relies on a incentive diversification effect that cannot be replicated by outside intermediaries. Joint liability clauses are chosen to implement a preferred Nash equilibrium in a multi-agent, multi-tasking game, where borrowers must be given incentives to be diligent as financed entrepreneurs and as monitors of others. Potential side contracting or collusion amongst borrowers is shown to only harm credit access, even when borrowers enjoy a monitoring advantage relative to outsiders.

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1 Introduction

Joint liability loan clauses such as those employed by the non-profit Grameen Bank of Bangladesh or the commercial Banco Solidario of Bolivia require that each member of a small circle of borrowers be liable for the loans of other members of the group should they become unable or unwilling to repay. The group loan methodology has been widely imitated and adopted and is celebrated as a contractual innovation that appears to achieve the apparent miracle of enabling previously marginalized borrowers to lift themselves up by their own bootstraps by creating 'social collateral' to replace the missing physical loan collateral that excluded them from access to more traditional forms of finance. Economists have taken notice, and by now a number of papers have proposed theoretical explanations for how joint liability clauses might work to create incentives for borrowers to peer-select, peer-monitor, or peer-sanction in ways that outside lenders might find difficult or costly to imitate in a variety of asymmetric information contexts.[1]

A few recent papers have, however, raised important questions about the purported optimality of joint liability loans in different contexts or have challenged the empirical validity of some of the assumptions upon which earlier arguments were premised. One obvious criticism is that several analyses of group loans have simply assumed that borrowers enjoy an information or enforcement advantage relative to outsiders. While such an information advantage may well be important in practice, joint liability loans cease to be quite as surprising or revolutionary once it has been made clear that 'closeness' amongst borrowers has been assumed rather than derived.[2]

[1] The case for group loans in the context of ex-ante moral hazard problems has been argued under different assumptions by Stiglitz (1990), Conning (1996), Madajewicz (1997), Armendariz de Aghion (1999) and Laffont and Rey (2000). The case for group loans to ameliorate the costs of ex-post moral hazard has been explored by Besley and Coate (1991), Bond (1998), Diagne (1998), Che (1999) and others. The adverse selection case has been explored by Ghatak (1999, 2000), Sadoulet (1998), van Tassel (1999), Wydick (1999), Armendariz de Aghion and Gollier (2000) and N'Guessan and Laffont (2000). Literature surveys include Ghatak and Guinnane (1999) and Morduch (1999).

[2] This explanation is the main interpretation found in recent literature surveys by Morduch (1999) and Ghatak and Guinnane (1999). Models where closeness amongst borrowers is derived rather than assumed include Conning (1996), Madajewicz (1997), Bond (1998), and Armendariz de Aghion and

A related line of criticism is that even if borrowers are better informed than outsiders, there may be ways other than joint liability contracts to get borrowers to truthfully reveal the information they hold about each other (Rai and Sjostrom, 2000).

Microfinance practitioners are themselves in no way in agreement about the relative merits of group loans. Critics contend that the purported benefits of group loans have been exaggerated and that the methodology is often overly rigid and poorly adapted to borrowers' needs. They argue instead for simpler individual liability loans monitored by locally recruited loan officers, which they claim achieve results that are every bit as good or better than group loans.[3] Even microlenders who have become world famous for their group loan methodology such as Grameen of Bangladesh do in fact also rely heavily upon highly motivated and locally recruited loan staff officers as monitors and organizers (Fuglesgang et al., 1993). This raises the important question of whether such delegated monitors might not be just as good at monitoring, and perhaps better at enforcing, loans than peer-monitors,[4] in which case joint liability clauses may be superflous or may be serving other purposes.

If joint liability loans in fact work by harnessing information that outsiders do not have, could it not instead be optimal to just hire one borrower, or another informed local, to act as a delegated monitor on behalf of a less informed outsider? Diamond (1984) has argued that when monitoring is itself costly and subject to moral hazard, there are advantages to concentrating monitoring activities in the hands of a single specialized monitor because the cost of providing incentives to the delegate are lower the more diversified are the returns in his portfolio of monitored projects. Since a specialized microfinance loan officer can often monitor as many as several hundred borrowers at once, diversification opportunities would seem to be good. Most joint liability loans in contrast typically involve two to five people, and rarely more than twenty. Peer-monitoring also seems to be more prone to free-rider problems in mon-

Gollier (2000).

[3]Morduch (2000) and Conning (1999) summarize some of the main policy disagreements in the field. One camp, the so called 'institutionists' tends to favor individual liability loans and financially sustainabile lending, while 'welfarists,' are more likely to support group loans and targeted outreach over financial sustainability.

[4]Diagne (2000) and Wydick (2000) report on survey evidence from Malawi and Guatemala that suggests that group borrowers may be quite reluctant to actively pressure delinquent group members. To paraphrase a commonly heard expression: 'the problem with co-signing for (or lending to) a friend is that not only may you lose your money, you may also lose a friend.'

itoring activities, particularly as group size increases, an issue that is not faced by a single specialized delegated monitor.

The purpose of this paper is to present a model that helps to answer the question of when joint liability loans will be optimal in the moral hazard context. When monitoring is costless, joint liability loans in fact offer no advantage over individual liability loans, unless borrowers are better informed than outsiders. However, when monitoring is a costly and imperfect activity (as it almost always surely is) joint liability loans can provide an advantage over individual liability loans *even when group peer-monitors have the same or even a less effective monitoring technology* than outside lenders or their delegated monitors.

Individual liability loans with costly delegated monitoring are modeled as in Holmstrom and Tirole (1997). Optimal joint liability loan contracts are modeled as a multi-task, principal-multiagent extension to this model, in which a lender engages each member of a group in two different capacities: as a borrower choosing actions on a lender-financed production project, and as a monitor of the other borrowers actions. Both monitoring and production activities are assumed to be costly and subject to moral hazard. Borrowers within a group are assumed to act non-cooperatively, but the contract must also guard against the possibility of collusion. Working within this setup, I will show that in a competitive loan market with heterogenous borrowers, some borrowers are offered and will choose joint liability loans, while other borrowers may prefer individual liability contracts.

'Monitoring' is interpreted as any activity that might directly affect a borrower's scope for moral hazard in the use of borrowed funds during the realization of the project. Monitoring need not involve direct observation of the borrower's actions. For example, a lender may choose to visit a borrower regularly, or to provide loans in-kind rather than as cash in order to increase the borrower's cost of diverting funds toward consumption or other projects that would harm the value of the financed activity.

The gain to employing group loans relies on an incentive diversification effect that cannot be reproduced under alternative individual liability using direct monitoring or delegated monitoring by outsiders. The reason is that joint liability places borrowers into a multi-task setting in which borrowers can be simultaneously rewarded for diligence in both production and monitoring, while incentives for each activity would have to be provided separately under individual liability contracts. This will be the case even if the playing field is completely leveled by giving delegated monitors the same or even slightly better monitoring technology than borrowers, and even if delegated monitors are made to simultaneously oversee a portfolio of borrowers to exploit incentive diversification opportunities, as in Diamond (1984).

The model also helps to clarify the roles that side contracting or collusion play in group loan design. The assumption of costless monitoring and full-side contracting that Stiglitz (1990) used to explain group loans, and that Holmstrom and Milgrom (1990), Itoh (1993), and Arnott and Stiglitz (1991) have employed in slightly different contexts, does not adequately describe the empirical observations of microfinance[5] Group participation is costly, and groups often fight and fall apart due to conflicts and opportunistic behavior. To capture this, in the present analysis borrowers can only monitor at a cost, they cannot observe each other's actions perfectly, and they choose their monitoring and production actions in a non-cooperative manner.

The rest of the paper is organized as follows. Section 2 summarizes and extends a benchmark individual liability monitored lending model under conditions of free entry and competition in the lending market. The model is shown to lead to three possibly optimal intermediary structures: collateralized bank loans with no monitoring, collateralized loans with a monitoring intermediary lender, and monitored loans from specialized moneylenders. Section 3 then analyzes group-loans, contrasting their properties to the lending arrangements of the previous section to show where each type of intermediary structure will be optimal. The latter part of the section discusses the role of collusion. Section 4 discusses further interpretations, extensions and limitations to the model, and section 5 concludes.

[5] Indeed one could argue that the defining characteristic of microfinance is that it requires costly monitoring to substitute for missing collateral. In their study of Grameen bank, Khanker and Pitt (1995) succinctly capture the issues when they state: "participation is costly, as group formation, training, and other group activities are time consuming and involve opportunity costs of time spent in group based activities ... [I]f there were not monitoring of the use of borrowed funds and group responsibility and decision making in the lending program, individuals would likely want to borrow much more than they actually do."

2 The Model

Consider a population of entrepreneurs who are identical in all respects except for their initial level of collateral assets A. Each entrepreneur has access to a simple production project that requires a non-recoverable lump sum investment I. Entrepreneurs do not have I and so they turn to the credit market. If the investment is made, the project generates stochastic but verifiable project returns of either x_s if the project is successful or x_f if it fails. Borrowing will be subject to moral hazard, however, because a borrower is assumed to be able to affect the probability of project success or failure through his actions, and this may in turn affect the lender's expected repayment. For example, a farmer who borrows \$100 to apply pesticide to a crop might decide to divert \$50 to another purpose and apply only half the recommended dosage, thereby increasing the probability that the crop is destroyed and that the loan cannot be repaid.

To fix ideas, suppose that when the entrepreneur diligently purchases inputs and applies labor effort as promised under a loan contract, the project succeeds with probability $\overline{\pi}$ and fails with probability $(1-\overline{\pi})$. When the borrower instead chooses to be non-diligent, say by diverting borrowed funds or effort away from the financed activity and toward other consumption or production activities, the probability of project success falls to $\underline{\pi} < \overline{\pi}$. Non-diligence generates private benefits $B(c)$ to the borrower which the lender cannot verify or seize. The value of the private benefits that the borrower may potentially capture are assumed, however, to be influenced by the level of 'monitoring' expenditure c that a lender or her delegate spends monitoring or otherwise trying to limit the size of those potential private benefits. Lenders may, for example, attempt to limit the borrower's scope for diverting cash from a fertilizer loan by providing the loan in kind, or by making frequent and unexpected visits to monitor the farmer's fields. Such activities, which are evidently costly for the lender to undertake, lower the net private benefits the borrower can capture through being non-diligent. It is reasonable to assume that the more that is spent on monitoring and control activities, the lower are the potential private benefits the borrower can expect from non-diligence, but that (eventually at least) there are diminishing returns to monitoring. Thus we assume that $B_c < 0$ and $B_{cc} > 0$.[6]

[6] Other monitoring technologies could be accomodated without altering the model's main

To focus attention on the cost of moral hazard, assume that the project is profitable under diligence but not profitable under non-diligence, even at zero monitoring:

$$E(x_i|\overline{\pi}) - \gamma I \geq 0 > E(x_i|\underline{\pi}) - \gamma I + B(0)$$

where $E(x|\overline{\pi}) = \overline{\pi} x_s + (1 - \overline{\pi}) x_f$ is the expected value of the project returns and γ is the market rate of return (one plus the interest rate) that the lender could have earned had I been left in a bank deposit. From the above expression it is evident that a producer who used his own investment resources I would never choose to be non-diligent.

2.1 Individual Liability Loan Contracts

Building on a version of the model considered by Holmstrom and Tirole (1997), this section examines the design of simple individual liability loans to borrowers with different initial levels of collateral to offer. These loans may or may not involve monitoring. We first analyze the simplest case of a lender who directly monitors borrowers herself, and then extend the analysis to lenders or investors who lend via other monitoring intermediary lenders or through hired loan staff. These scenarios give us benchmarks against which we can later compare joint liability lending.

Most investors rely on delegated monitors in their own lending activities. For example, bank owners hire loan officers. Another typical situation is that banks choose to lend money I^u to firms or other financial intermediaries who in turn on-lend these funds plus some of their own funds I^m to a final set of borrowers. In this case the bank is helping to finance these borrowers via the intermediary. Formally, all that really distinguishes the loan officer from the intermediary lender is the degree of liability that the delegated monitor must assume in the event that the final borrowers' project fails. The loan officer's liability for loan failures will typically be limited by law, while an intermediary lender risks losing up to the amount of funds I^m she has

predictions. For example, an initial indivisibility (e.g. monitoring requires a fixed monitoring setup cost) would imply that monitoring expenses only have effects above some minimum threshold. One might also at first assume increasing or constant returns to monitoring ($B_{cc} \leq 0$) before diminishing returns set in ($B_{cc} > 0$).

placed at risk in the borrower's project. In either case the outside investor presumably prefers to work via a delegated monitor or intermediary rather than lend directly to the final borrower because the intermediary has a better monitoring technology.

Suppose entrepreneurs' project returns are independent from one another. The loan market is assumed to be competitive with free entry into both lending and intermediation activities. Consider first the case of a delegated monitor who lends I^m of her own capital and attempts to leverage the remainder $I^u = I - I^m$ from an uninformed outside investor. The contract design problem involves deciding on how to divide available project outcomes x_i between repayments to an uninformed lender R_i, payments to a delegated monitor w_i, and returns to the borrower $s_i = x_i - R_i - w_i$.[7]

The sequence of actions is as follows. A contract is proposed that may or may not involve a delegated monitor. If a monitor is to be involved, then the monitor chooses her own preferred monitoring strategy which involves spending resources c. Aware of this monitoring activity, the borrower then chooses his unobserved diligence level π. Finally, claims to the observed project outcome are divided according to the terms of the agreed contract. Assuming a competitive lending market with free entry into both the uninformed and monitored lending activities, the optimal contract $\{s_i, w_i\}$ for a borrower with collateral assets A will solve the following program:

$$\max_{w_i\,,\,s_i} E(s_i|\overline{\pi})$$

$$E(R_i|\overline{\pi}) \geq \gamma I^u \tag{1}$$

$$E(w_i|\overline{\pi}) - c \geq \gamma I^m \tag{2}$$

$$E(s_i|\overline{\pi}) \geq E(s_i|\underline{\pi}) + B(c) \tag{3}$$

$$E(w_i|\overline{\pi}) - c \geq E(w_i|\underline{\pi}) \tag{4}$$

$$s_i \geq -A \qquad\qquad i = 1, 2 \tag{5}$$

$$I^m + I^u = I, \quad R_i = x_i - w_i - s_i$$

where (1) is the investor's participation constraint or break-even constraint, (2) is

[7] The case of a bank loan officer will later be shown to just involve imposing an additional limited liability constraint equivalent to $I^m = 0$ and $w_f = 0$.

the delegated monitor's break-even condtion, (3) is the borrower's incentive compatibility constraint, (4) is the monitor's incentive compatibility constraint, and (5) are the borrower's limited liability constraints. The uninformed lender's break-even constraint requires that this lender earn at least as much from expected repayments as she could earn by leaving the same funds I^u in a bank deposit. The intermediary's participation constraint (2) states that the expected value of repayments w_i to an intermediary who lends I^m of her own funds and monitors at optimal intensity c must at least equal what the intermediary could have earned from the bank net of the monitoring expense.

The borrower's limited liability constraint (5) expresses the fact that total repayments from the borrower to the lender(s) following any given project outcome x_i may not exceed the value of that project outcome plus the borrower's pledged collateral assets A, or $R_i + w_i \leq x_i + A$. Inequality (5) is obtained by re-arranging noting that $R_i + w_i = x_i - s_i$.

The borrower's incentive compatibility constraint can be rearranged to yield the more convenient expression:

$$s_s - s_f \geq \frac{B(c)}{\Delta\pi}$$

where $\Delta\pi = (\overline{\pi} - \underline{\pi})$. This reveals that an optimal contract will require the borrower to earn more from successful outcomes than from failures so as to provide an incentive to raise the probability of success via diligence.

If the contract is to involve any monitoring, the intermediary will also face an incentive constraint because her monitoring actions are not observed by the outsider lender. Since monitoring lowers the borrower's private benefit $B(c)$ at expense c which in turn raises the borrower's incentive to raise the probability of the project being a success, the contract should reward the intermediary for the borrower's successes and punish him for failures. This can be seen clearly when the intermediary's incentive compatibility constraint (4) is rewritten as $w_s - w_f \geq \frac{c}{\Delta\pi}$.

The assumption of free entry into the monitoring activity assures that the monitor's participation constraint (2) must be binding and that $w_f - \gamma I^m \leq 0$.[8] As monitors

[8] This follows because (2) implicitly assumes that the monitor's outside reservation income is zero. If $w_f - \gamma I^m > 0$ the incentive constraint (4) would then require $w_s - \gamma I^m \geq w_f - \gamma I^m + \frac{c}{\Delta\pi} > 0$ and the monitor would be earning a strictly positive enforcement rent $E(w|\overline{\pi}) - \gamma I^m - c > 0$. But then the borrower would switch to another monitored arrangement where the monitor's expected

are risk neutral, there are in fact an infinite number of $\{w_f, w_s\}$ combinations that would keep the monitor at his reservation utility and at the same time satisfy the incentive constraint. Without loss of generality we can focus on contracts in which the monitor's incentive constraint also binds. This then implies that if monitoring takes place, then $w_f = 0$ and $w_s = \frac{c}{\Delta\pi}$, with c still to be determined. Note that since then $E(w_i|\overline{\pi}) = \overline{\pi}\frac{c}{\Delta\pi}$ the monitor's binding (zero profit) participation constraint then implies

$$\gamma I^m = \overline{\pi}\frac{c}{\Delta\pi} - c > 0 \tag{6}$$

where the last inequality holds strictly whenever $\overline{\pi} > \underline{\pi} > 0$ and $c > 0$. Hence when $c > 0$ the contract calls for the monitor to acquire a strictly positive stake in the borrower's project by lending $I^m > 0$ out of her own equity, to leverage a remaining $I^u = I - I^m$ from an uninformed outside lender.

Can a borrower with assets A credibly commit to repayments that are sufficient to cover the lender's opportunity cost of funds and monitoring costs? From the limited liability constraint it is evident that the most that a borrower can commit to pay in the failure state is the full value of output x_f plus any pledged collateral resources A. Thus $R_f + w_f = x_f + A$, or $s_f = -A$. A large payment following success $R_s + w_s = x_s - s_s$ in turn requires s_s to be as small as possible, but by limited liability the lowest s_f can be is $s_f = -A$, and by the incentive constraint, s_s must be no smaller than $s_s = s_f + B(c)/\Delta\pi = -A + B(c)/\Delta\pi$. If both the incentive compatibility and limited liability constraints are to be met, the borrower must therefore earn a minimum rent or a minimum expected return $E(s_i|\overline{\pi}) = -A + \overline{\pi}\frac{B(c)}{\Delta\pi}$. Substituting this minimum expected return and $E(w_i|\overline{\pi})$ into the investor's break-even condition yields:

$$\begin{aligned}
E(x_i|\overline{\pi}) - E(s_i|\overline{\pi}) - E(w_i|\overline{\pi}) &\geq \gamma I^u & (7)\\
E(x_i|\overline{\pi}) - \left(\overline{\pi}\frac{B(c)}{\Delta\pi} - A\right) - \overline{\pi}\frac{c}{\Delta\pi} &\geq \gamma I - \gamma I^m & (8)\\
E(x_i|\overline{\pi}) - \overline{\pi}\frac{B(c)}{\Delta\pi} + A - \overline{\pi}\frac{c}{\Delta\pi} &\geq \gamma I - \overline{\pi}\frac{c}{\Delta\pi} + c & (9)\\
E(x_i|\overline{\pi}) - \gamma I &\geq \overline{\pi}\frac{B(c)}{\Delta\pi} - A + c & (10)
\end{aligned}$$

rent is smaller. Competition to provide monitoring services means this rent must be driven to zero, or $w_f - \gamma I^m \leq 0$.

If the lender's break even condition is not satisfied, no loan will be available to this type of borrower. The expression above states that lending will take place so long as net project returns $E(x_i|\overline{\pi}) - \gamma I$ exceed the borrower's rent plus the monitoring costs required for a borrower with collateral assets A. This immediately suggests an inefficiency, as there are positive net present value projects that will not be funded.

All that remains is to find the contract within this feasible set that is most preferred by the borrower. In this competitive lending market, the monitor and the uninformed lender's participation constraints both bind and the borrower's expected return is simply

$$E(s_i|\overline{\pi}) = E(x_i|\overline{\pi}) - \gamma I - c$$

from which it is obvious that the borrower is best off using as little monitored lending as possible. How far monitoring can be lowered without disrupting incentives depends on the borrower's collateral holdings. A convenient way to focus on the problem is to search for the locus of monitoring c and collateral A combinations at which lenders just break even and are willing to participate. Rearranging the binding uninformed lender's participation constraint (10), we can solve for $\underline{A}(c)$ or the minimum level of collateral consistent with a given monitoring intensity c :

$$\underline{A}(c) = \overline{\pi}\frac{B(c)}{\Delta\pi} - E(x|\overline{\pi}) + \gamma I + c \tag{11}$$

Whether monitoring lowers the minimum collateral requirement on a loan depends on the nature of the monitoring technology. There are two effects. On the one hand, monitoring lowers the borrower's private benefits from non-diligence. On the margin this relaxes the borrower's incentive compatibility constraint by $\overline{\pi}\frac{B_c(c)}{\Delta\pi}$ and hence the rent that must be left with the borrower, and this lowers the collateral requirement. On the other hand, monitoring is a costly activity which must be paid, so every extra dollar's worth of monitoring eats away at the project surplus from which repayments can be made. This second effect raises the collateral requirement. Assume that the first dollar spent on monitoring has a net effect of lowering the collateral hurdle, or $\overline{\pi}\frac{B_c(0)}{\Delta\pi} > -1$, so monitoring is at first useful in reducing the collateral requirement. The assumption of diminishing returns to monitoring $(B_{cc} > 0)$ guarantees, however, that there eventually will be some monitoring intensity $\overline{c}$ beyond which no further monitoring is worthwhile. The cutoff $\overline{c}$ is defined by the condition $\overline{\pi}\frac{B_c(\overline{c})}{\Delta\pi} = -1$. Beyond $\overline{c}$ the marginal benefit of an extra dollar of monitoring exceeds its marginal cost and therefore is not worthwhile. Figure 1 illustrates how the minimum collateral requirement might fall over the range $(0, \overline{c})$ and rise thereafter.

Figure 1 about here

Because monitoring eats up real resources, monitored lending is always more expensive than uninformed lending. It follows that only borrowers with assets below $\underline{A}(0)$ who cannot gain access to direct bank loans turn to this form of finance and then choose loans that involve only as much monitoring as is minimally required to lower the collateral requirement to their available collateral asset level A. The optimal monitoring level is therefore given implicitly by $A = \underline{A}(c)$, or equivalently by $c(A) = \underline{A}^{-1}(A)$, where A is the borrower's initial collateral wealth.

Since the borrower makes expected payments of $\gamma I + c(A)$ on I dollars borrowed, the implicit interest rate is $\gamma + \frac{c(A)}{I}$ which is non-increasing in the borrower's collateral A. Poorer borrowers therefore pay higher implicit interest rates and also have a larger proportion of monitored lending I^m in their total finance package. This last point can be seen by the fact that $\gamma I^m = \overline{\pi}\frac{c(A)}{\Delta\pi} - c(A)$ rises with $c(A)$ and therefore falls with A.

As we move through borrowers with less and less initial collateral wealth, it is possible that monitoring intensity will rise until it has reached a point $\widehat{c}$ defined by $\gamma I^m = \overline{\pi}\frac{\widehat{c}}{\Delta\pi} - \widehat{c} = \gamma I$. At this point so much monitoring is needed that the intermediary's required liability I^m equals the full lump sum investment I: hence no outside leverage is possible. Borrowers with less than $\underline{A}(\widehat{c})$ in collateral therefore can obtain loan size I only from a lender who lends entirely out of her own equity. Several studies of rural credit markets have characterized informal moneylenders in precisely these terms: moneylenders lend primarily out of own equity, they monitor their borrowers very heavily, and they charge high interest rates (Aleem, 1994; Bell, 1994). Monitoring intensity eventually reaches level $\overline{c}$, beyond which further monitoring becomes simply unprofitable. This defines an absolute minimum collateral requirement $\underline{A}(\overline{c})$, below which borrowers will be excluded entirely from the loan market.[9]

[9] I've assumed that the borrower's own participation constraint does not bind before

2.2 Delegation costs

Thus far we have assumed that a delegated monitor could always be made sufficiently liable for a borrower's project failure by the requirement that she lend I^m out of her own equity, and competition amongst intermediaries drove the monitor's profits to zero. From the borrower's standpoint the loan terms would have been exactly the same had we simply had the bank monitor the borrower directly with the same monitoring technology $B(c)$ rather than via a delegate. It is not always reasonable to assume that a bank can find delegated monitors with enough intermediary capital to service all markets. In many poor communities the agents most likely to have access to the best monitoring technology may be poor themselves. Commercial banks cannot ask their hired loan staff to assume liability for their borrowers' project failures.

This case can be modeled by assuming that $\gamma I^m = 0$ and imposing a limited liability constraint $w_f \geq 0$ for the delegate . Competition in monitoring activities then assures that this constraint will bind and that any optimal contract will set $w_s = \frac{c}{\Delta\pi}$. The monitor must now also earn a rent or delegation cost $E(w_i|\overline{\pi}) - c = \overline{\pi}\frac{c}{\Delta\pi} - c > 0$, for just the same reason that the collateral-poor borrower earns a rent. Substituting this delegation cost into the derivations above yields a new expression describing the minimum collateral requirement associated each monitoring intensity:

$$\underline{A}^d(c) = \overline{\pi}\frac{B(c)}{\Delta\pi} - E(x|\overline{\pi}) + \gamma I + \overline{\pi}\frac{c}{\Delta\pi} \tag{12}$$

It is easy to see that the relationship between this expression and the earlier expression (11) for $\underline{A}(c)$ is $\underline{A}^d(c) = \underline{A}(c) - c + \overline{\pi}\frac{c}{\Delta\pi} = \underline{A}(c) + \gamma I^m$. Hence $\underline{A}^d(c) > \underline{A}(c)$ at every level of c, which in turn implies that loans monitored by delegated monitors such as hired staff are in general more expensive than loans where the delegate can be made liable. As discussed above, an insight from Diamond (1984) suggests that these delegation costs might be pushed down by placing each loan officer in charge of a portfolio of monitored borrowers with diversified project returns. If this argument is pushed to its limit, we are back to $\underline{A}(c)$.

monitoring level $\overline{c}$ is reached. If the farmer's has a reservation utility given by K, then his binding participation constraint $E(s_i|\overline{\pi}) = E(x_i|\overline{\pi}) - \gamma I - c = K$ defines a cutoff level $c^k = E(x_i|\overline{\pi}) - \gamma I - K$. I assume therefore that $\overline{c} \leq c^k$.

3 Joint Liability Loans

Group lending arrangements delegate the task of monitoring to the borrowers themselves rather than to an outside monitor. One obvious potential advantage of this approach that has been frequently mentioned in the literature is that borrowers may be more effective monitors because they belong to the same social networks and may already interact in other economic exchange relationships. But joint liability loans may offer advantages that go beyond this effect.

In a peer-monitored loan each member of the group must be given incentives to act both as a borrower choosing diligence π on his financed production project and as a delegated monitor choosing the optimum intensity c at which to monitor and/or otherwise attempt to control the actions of other members in the group. Since neither activity is observable to an outside lender, the structure of the problem is that of a multi-task principal-multi-agent problem.

Consider the joint liability contract between a single uninformed lender and a symmetric two-member group. Symmetry allows us to economize on notation and describe the contract terms primarily from the perspective of borrower one, except where ambiguity might arise. For example, x_i^n denotes project outcome i for borrower n. Let s_{ij} denote the contractual return to borrower one following an outcome x_i^1 on his own project and an outcome x_j^2 on borrower two's project. Because there are four possible joint outcomes, the joint-liability reward schedule for the borrower is $(s_{ss}, s_{sf}, s_{fs}, s_{ff})$. Assume that the two borrowers' project returns are statistically independent, so the joint probability of observing output pair (x_i^1, x_j^2) is given simply by $\Pi(\pi_i^1, \pi_j^2) = \pi_i^1 \cdot \pi_j^2$. While this assumption is restrictive, it helps to distinguish clearly the mechanism analyzed here from other explanations for why repayment rules might be made to be interdependent as suggested for, example, by the literature on relative performance evaluation (Holmstrom, 1979; Mookherjee, 1984).

Just as the outside intermediary monitor could not, group members cannot observe each other's diligence level in production directly. Nor need we assume that monitoring intensities are directly observed. Borrowers only infer what the other borrower's production and monitoring actions are likely to be from the known terms of the contract, and they choose their own actions accordingly.

In order to isolate more starkly the mechanism at work it will be useful to assume that the monitoring technology employed by the borrowers *cum* monitors is *exactly the same* as the one used by the outside delegated monitor in the last section. A borrowers can thus lower the private rewards $B(c)$ that the other borrower stands to obtain from non-diligence by dedicating time and resources c to monitoring. One might well imagine, especially in the context of small tight-knit communities that peer-monitoring in fact operates through somewhat different channels than monitoring by an outsider. For example, a borrower might simply be less likely to divert funds to private purposes because he would feel more guilty or be more likely to face costly social retaliation for cheating on a friend or community member than he would for cheating on a bank clerk or hired intermediary to whom he owes no particular allegiance. This would especially be the case when that friend or community member has demonstrated a willingness to bear liability for the borrower's failures and has spent time and energy on the group project.[10] On the other hand, collusion also seems more likely to occur amongst borrowers.

The contracting problem can be thought of as a mechanism design problem. The terms of the contract s_{ij} will determine the payoff structure of a game in monitoring intensities and production action choices played by two borrowers. Figures 2 and 3 depict the game played between two borrowers joined together by contract $\{s_{ij}\}$. At a first game stage borrowers play a non-cooperative game in monitoring intensities. Any given monitoring intensity pair (c^1, c^2) chosen at the first stage then determines the payoff structure $\zeta(c^1, c^2)$ of a subgame in action choices at the second stage. We search for a pure strategy subgame-perfect Nash equilibrium (SPNE) implementation. The desired outcome is that each borrower choose an equilibrium monitoring intensity c at a first game stage which then helps implement diligence choice $\overline{\pi}$ as the equilibrium outcome in a second stage game in production actions. As monitoring is an expensive activity, an optimal contract aims to keep the value of c as low as is consistent with sustained incentives.

Figures 2 and 3 about here

[10] Pitt and Khandler (1995) describe the near-religious fervor that is at times generated and expected from group members in the Grameen Bank. Social presure is placed on members to attend meetings at which they make solemn oaths to one another and to the principles of the bank. This type of actions seems clearly aimed at making group members internalize feelings of guilt or remorse for taking actions that harm the group while feeling pride or joy for actions that contribute.

For a given contract s_{ij} the expected *monetary* return to borrower One from his production activity is denoted $E(s_{ij}|\pi^1, \pi^2)$. The final payoff to each borrower must, however, also subtract out the costs of monitoring and add in any private benefits that might have been captured. A joint liability structure will require that $s_{ss} \geq s_{sf}$ and $s_{fs} \geq s_{ff}$ with at least one strict inequality. In other words, one borrower's return is increasing in the other borrower's measured performance.[11]

The following proposition characterizes the structure of incentive compatible group loan contracts, while the discussion below establishes when group loans will be offered in a competitive lending market and chosen ahead of other forms of financial intermediation.

Proposition 1 *Define*

$$\underline{A}^g(c) = \overline{\pi}\frac{B(c)}{\Delta\pi} - E(x|\overline{\pi}) + \gamma I \tag{13}$$

and

$$\underline{\underline{A}}^g(c) = \overline{\pi}\left[\frac{B(0)+c}{\overline{\pi}^2 - \underline{\pi}^2}\right] - E(x|\overline{\pi}) + \gamma I \tag{14}$$

If $B_c(0) < -\frac{1}{\overline{\pi}}$, then a symmetric joint liability loan contract s_{ij} will be available to borrowers with collateral assets $A \in (\underline{A}^g(0), \underline{\underline{A}}^g(c^g))$ where c^g is defined by $\underline{A}^g(c^g) = \underline{\underline{A}}^g(c^g)$. The group contract induces monitoring intensity $c(A)$ implicitly defined by $A = \underline{A}^g(c)$. The optimal contract s_{ij} hasthe following simple structure $s_{ss} = Z(c) - \underline{A}^g(c)$, $s_{sf} = s_{fs} = s_{ff} = -\underline{A}^g(c)$, where $\underline{A}^g(c)$ is defined as above and $Z(c) = \frac{B(c)}{\overline{\pi}\Delta\pi}$.

An overall explanation and economic intuition for interpreting the result follows below, but details of the proof are relegated to the appendix. The following functions which summarize payoffs to borrower one in each of the four cells of subgame $\zeta(c^1, c^2)$ will be useful (see figure 5 and discussion in the appendix):

$$\begin{aligned}
&DD(c^1, c^2) : E(s_{ij}|\overline{\pi}, \overline{\pi}) - c^1 \\
&ND(c^1, c^2) : E(s_{ij}|\underline{\pi}, \overline{\pi}) - c^1 + B(c^2) \\
&DN(c^1, c^2) : E(s_{ij}|\overline{\pi}, \underline{\pi}) - c^1 \\
&NN(c^1, c^2) : E(s_{ij}|\underline{\pi}, \underline{\pi}) - c^1 + B(c^2)
\end{aligned} \tag{15}$$

[11] This is in contrast to a relative performance evaluation contract which requires one borrower's reward to be decreasing in the other borrower's measured performance.

For example $ND(c^1, c^2) = E(s_{ij}|\underline{\pi}, \overline{\pi}) - c^1 + B(c^2)$ is the final payoff to borrower 1 when he is non-diligent (chooses $\underline{\pi}$) and monitors the other borrower at intensity c^1 while borrower 2 chooses diligence and monitors borrower 1 at intensity c^2.

If a contract is to implement the diligence strategy profile $(\overline{\pi}, \overline{\pi})$ as a Nash equilibrium in subgame $\zeta(c, c)$ then the following incentive compatibility constraint must be met for borrower 1 (and symmetrically for borrower 2):

$$DD(c, c) \geq ND(c, c) \tag{16}$$

Writing out this inequality, substituting the proposed solution structure from Proposition 1, and rearranging yields:

$$\overline{\pi}\overline{\pi}Z(c) - \underline{A}^g(c) - c \geq \overline{\pi}\underline{\pi}Z(c) - \underline{A}^g(c) + B(c) - c$$

$$Z(c) \geq \tfrac{B(c)}{\overline{\pi}\Delta\pi}$$

where as before $\Delta\pi = (\overline{\pi} - \underline{\pi})$. This expression can be substituted into the investor's binding participation constraint for each borrower[12]

$$E(R_{ij}|\overline{\pi}, \overline{\pi}) = E(x|\overline{\pi}) - E(s_{ij}|\overline{\pi}, \overline{\pi}) = \gamma I$$

As before, this expression allows us to solve for the minimum collateral requirement at which an investor would just break even:

$$E(x|\overline{\pi}) - \overline{\pi}\overline{\pi}Z(c) + \underline{A}^g(c) = \gamma I$$

$$\underline{A}^g(c) = \overline{\pi}\tfrac{B(c)}{\Delta\pi} - E(x|\overline{\pi}) + \gamma I$$

This is (13) in the Proposition.

Another condition that the contract must meet is that the borrowers not have the incentive to accept the contract but then collude to choose any action pair other than the equilibrium outcome we wish to implement. As is explained in the appendix, it will be enough to require that the borrowers prefer the payoffs they obtain from choosing diligence and optimal monitoring intensity c to what they could obtain by

[12] The expression exploits symmetry to express the investor's constraint only in terms of farmer One's expected project outcome and return.

choosing not to monitor each other and choosing non-diligence:

$$\begin{aligned} DD(c,c) &\geq NN(0,0) \\ E(s_{ij}|\overline{\pi},\overline{\pi}) - c &\geq E(s_{ij}|\underline{\pi},\underline{\pi}) + B(0) \end{aligned} \tag{17}$$

Writing this inequality out in full yields:

$$\begin{aligned} &\overline{\pi}\overline{\pi}s_{ss} + \overline{\pi}(1-\overline{\pi})s_{sf} + (1-\overline{\pi})\overline{\pi}s_{fs} + (1-\overline{\pi})^2 s_{ff} - c \geq \\ &\underline{\pi}\underline{\pi}s_{ss} + \underline{\pi}(1-\underline{\pi})s_{sf} + (1-\underline{\pi})\underline{\pi}s_{fs} + (1-\underline{\pi})^2 s_{ff} + B(0) \end{aligned} \tag{18}$$

A little thought reveals that this constraint can be met at minimum collateral expense by using a 'live or die' contract structure such that the proposed contract places as much of the borrower's reward on s_{ss} while setting the other s_{ij} as low as possible (which by the limited liability means full payment out of collateral).[13] This is optimal because the joint outcome x_{ss} in general provides the sharpest possible signal that the borrower-cum-monitor has chosen the desired $\overline{\pi}$ and c and the theory of optimal contract design dictates that maximum reward be placed on the most informative signals (Holmstrom, 1979).[14] The diversification effect described in Stiglitz' (1990) and Laffont and Rey (2000) relies essentially on this result. The difference here is that the diversification is shown to operate at the level of each individual borrower and to involve diversification between the production and the costly monitoring activity.

Substituting a contract of the proposed shape into expression (17) above yields:

$$\overline{\pi}\overline{\pi}Z(c) - \underline{A}^g(c) - c \geq \underline{\pi}\underline{\pi}Z(c) - \underline{A}^g(c) + B(0)$$

$$Z(c) \geq \frac{B(0)+c}{\overline{\pi}^2 - \underline{\pi}^2}$$

which, after substitution into the investor's participation constraint requires that the

[13] As explained by Innes (1990), live-or-die financial contracts are optimal in contracting situations with risk neutral agents and limited liability. Standard debt contracts emerge as optimal once additional monotonicity constraints (which can be given good economic justification in the context of many credit markets) are imposed.

[14] It can be shown that x_{ss} will in general provide the most informative signal whenever $\overline{\pi} > \underline{\pi} \geq \frac{1}{4}$.

minimum collateral requirement also meet the following restriction:

$$\underline{\underline{A}}^g(c) = \overline{\pi}\left[\frac{B(0)+c}{\overline{\pi}^2 - \underline{\pi}^2}\right] - E(x|\overline{\pi}) + \gamma I \geq \underline{A}^g(c)$$

which is expression (14). In figure 4 the locus of points above the rising diagonal line $\underline{\underline{A}}^g(c)$ satisfy this relationship.

Comparing the monitoring and collateral characteristics of the joint liability contract to the individual liability loan contracts of the previous section is instructive. A little rearranging of (13) demonstrates that the relationship between the two collateral requirements is simply:

$$\underline{A}^g(c) = \underline{A}(c) - c$$

The cost of the monitoring expense is not added in the group loan as it is to the minimum collateral requirement of the loan with an outside monitoring intermediary. The intuition for this result is very simple. Borrowers with an outside monitor need to commit credibly to making repayments to cover lenders' opportunity cost of funds *as well as* the monitoring expense incurred by an outside monitor. In a group loan, in contrast, borrowers need only pledge to make outside repayments that cover the opportunity cost of outsiders' funds, as the monitoring cost is borne within the group. The monitoring costs in the group use up resources just as surely as the costs borne by the outsider, but these monitoring costs can be subtracted out of the borrower's enforcement rent without disrupting incentives.

It is worth remarking that the optimal joint liability contract is not just a linear combination of the contract terms as if separately providing incentives to borrowers as producers and as monitors. If we had instead used $s_{ij} = s_i + w_j$, where s_i is the borrower's reward for outcomes on his project and w_j is his reward tied to outcomes on the other borrowers project, and both are defined as under the individual liability monitored loan contract above[15], a degree of joint liability would be achieved, but not enough. In fact, this contract delivers us back at expression $\underline{A}^d(c)$ in (12), the expression for the collateral requirements monitored loan contracts when the delegated monitors were hired staff members who could not post bond. The borrowers in a group loan are in exactly the same situation: already short on collateral to obtain a non-monitored loan, they will not have additional collateral to bond themselves as

[15]In other words $s_{ss} = \frac{B(c)+c}{\Delta\pi} - A$, $s_{sf} = \frac{B(c)}{\Delta\pi} - A, s_{fs} = \frac{c}{\Delta\pi} - A, s_{ff} = -A$

monitors.

The comparison reveals the 'collateral diversification' effect at work. Compared to the $s_{ij} = s_i + w_j$ scheme just described, the optimal contract sharpens incentives in several respects. Incentives to both monitoring and production diligence are sharpened by piling greater reward on the joint outcome success-success s_{ss}, while incentives to production diligence are increased by penalizing a borrower with a successful project outcome when his monitoree's project fails. Finally, incentives to monitoring are sharpened by taking away from the reward to monitoring received when the other borrower's project success but one's own production fails.[16]

Figures 4 about here

A reasonable objection might be raised at this point. Couldn't an outside monitor also also take advantage of diversification effects? From Diamond (1984) we know that the delegation costs of using an intermediary monitor fall as the monitor's portfolio of monitored borrowers becomes larger and more diverse. It is easy to see, however, that this does nothing to help reduce the total costs of lending under the individual liability modality because by construction the delegated monitor-lender earned no enforcement rent and so delegation costs were already zero. Diversification effects would help lower the delegation costs of employing hired staff who cannot post bonds, or lower the amount of capital I^m the delegate needs to have at stake in each borrower's project. In either case, however, it is the need to repay an outside monitor for his monitoring expense c which is adding to the cost of operating under individual liability loans.

Summarizing the discussion thus far, peer-monitored loans therefore do offer an advantage over outside monitored loans, and this advantage does not rest upon a presumed information advantage held by insiders. Any information or enforcement advantage that group members may have relative to an outside intermediary will of course only strengthen the advantage.

The scope for employing group loans will be limited, however, by lenders fear that borrowers could collude against a lender and will guard against this possibility by only agreeing to collusion-proof loans.[17] Figure 4 shows that group loan contracts

[16] Compare the shape of the optimal contract described in Proposition 2 to the non-optimal contract described in the previous paragraph and footnote.

[17] By collusion I refer to the possibility that borrowers might coordinate on a different Nash

will not be offered to any borrower with assets below $A(c^g)$, because these borrowers cannot commit to not colluding together against the lender. As depicted, some poorer borrowers with assets below this cutoff may still obtain funding from loans monitored by more expensive moneylenders or intermediaries. As in the scenario described in the previous section, the poorest of the poor – those below $A(\overline{c})$ remain excluded from the credit market entirely. This result is consistent with many analyses that suggest that even Grameen Bank is not really lending to the poorest of the poor (Morduch, 1999).

The model predicts that implicit interest charges will be lower on group loans compared to outside monitored loans for borrowers in the same asset class. Note that the explicit money interest charges on group loans are always γI for all qualifying borrowers, although of course the total cost of funds to the borrower must also include the cost of monitoring others. We again find that the implicit interest rate of borrowing is rising as the borrower's collateral requirements decrease. However when joint liability loans are optimal, they will be chosen by borrowers because they offer a equal or lower total cost of borrowing for any given level of collateral.

3.0.1 Full Side-Contracting and costless monitoring

It is instructive to compare the results of this paper to related discussions such as Stiglitz (1990) and Laffont and Rey (2000) who assume that information in the group is shared (monitoring costs are nil) and that borrowers can fully side-contract on both efforts and transfers. Under the assumptions that monitoring is costless and perfectly reveals diligence effort and that borrowers can fully side contract, the group will behave as a single supra-individual who acts to maximize joint profits. The relevant incentive constraint for the group is then:

$$2\left(\overline{\pi}\overline{\pi}s_{ss} + \overline{\pi}(1-\overline{\pi})s_{sf} + (1-\overline{\pi})\overline{\pi}s_{fs} + (1-\overline{\pi})^2 s_{ff}\right) \geq$$
$$2\left(\underline{\pi}\underline{\pi}s_{ss} + \underline{\pi}(1-\underline{\pi})s_{sf} + (1-\underline{\pi})\underline{\pi}s_{fs} + (1-\underline{\pi})^2 s_{ff} + B(0)\right)$$

This expression exploits the symmetry of payoffs and states that group members must prefer to both be diligent rather than both be not diligent. As above a little

equilibrium in the action subgame that is less preferred by the lender. This is different from collusion in the sense of costlessly side-contracting against the lender, as described in the next subsection.

reflection will suggest that to also satisfy limited liability the optimal contract will be of the form $s_{ss} = Z - A$ and $s_{ij} = -A$ for all other i, j. Substituting into the lender's break-even condition and solving for Z, we arrive at an average payoff per borrower of

$$E(s_{ij}|\overline{\pi}\overline{\pi}) = \overline{\pi}\overline{\pi}\frac{B(0)}{\overline{\pi}\overline{\pi} - \underline{\pi}\underline{\pi}}$$

from both being diligent. By construction this is a higher average payoff than if neither were diligent. It remains to be checked whether the group prefers both being diligent to only one borrower being diligent. That this will be the case can be seen by comparing group payoffs in each case:

$$\begin{aligned}
2\overline{\pi}\overline{\pi}\frac{B(0)}{\overline{\pi}\overline{\pi} - \underline{\pi}\underline{\pi}} - 2A &\geq 2\underline{\pi}\overline{\pi}\frac{B(0)}{\overline{\pi}\overline{\pi} - \underline{\pi}\underline{\pi}} + B(0) - 2A \\
2\overline{\pi}\overline{\pi}B(0) &\geq 2\underline{\pi}\overline{\pi}B(0) + B(0)(\overline{\pi}\overline{\pi} - \underline{\pi}\underline{\pi}) \\
\overline{\pi}\overline{\pi} &\geq 2\underline{\pi}\overline{\pi} - \underline{\pi}\underline{\pi} \\
\overline{\pi}(\overline{\pi} - \underline{\pi}) &\geq \underline{\pi}(\overline{\pi} - \underline{\pi})
\end{aligned}$$

which is always satisfied as $\overline{\pi} \geq \underline{\pi}$.

Full side-contracting cannot always be assumed, however. Borrowers in a group who agreed to the above contract would be tempted to defect from the equilibrium unless the group had a strong commitment technology that allowed them to follow through on promised side transfers. To see this note that defection is worthwhile to any one borrower so long as:

$$\underline{\pi}\overline{\pi}\frac{B(0)}{\overline{\pi}\overline{\pi} - \underline{\pi}\underline{\pi}} + B(0) - A > \overline{\pi}\overline{\pi}\frac{B(0)}{\overline{\pi}\overline{\pi} - \underline{\pi}\underline{\pi}} - A$$

which is always met for $\overline{\pi} \geq \underline{\pi}$. One borrower's defection raises his personal payoff at the expense of joint profits. When full side contracting is not possible in this no-monitoring environment, a group loan contract must satisfy the additional individual incentive constraints:

$$\overline{\pi}\overline{\pi}s_{ss} + \overline{\pi}(1-\overline{\pi})s_{sf} + (1-\overline{\pi})\overline{\pi}s_{fs} + (1-\overline{\pi})^2 s_{ff} \geq$$

$$\underline{\pi}\overline{\pi}s_{ss} + \underline{\pi}(1-\overline{\pi})s_{sf} + (1-\underline{\pi})\overline{\pi}s_{fs} + (1-\underline{\pi})(1-\overline{\pi})s_{ff} + B(0)$$

which leads us to an optimal contract of the form $s_{ss} = Z - A$ and $s_{ij} = -A$ for all other i, j where Z is given by $Z = \frac{B(0)}{\overline{\pi}\Delta\pi}$ and a per borrower payoff of $\overline{\pi}\frac{B(0)}{\Delta\pi} - A$. Note that in this costless monitoring this payoff is exactly the same as what the borrower would get under an individual liability contract. In other words, the gain to employing joint liabibility loans in a costless monitoring environment collapses once the ability of agents to side-contract or 'collude' is taken away. When monitoring is costly, however, an additional gain to joint liability does emerge. Even when borrowers cannot side contract, a group can economize on incentive costs because the group can absorb monitoring costs that would have had to have been credibly pledged to an outside monitor under an individual liability lending arrangement.

3.1 Discussion and Extensions

A joint liability contract in effect forces borrowers to divest themselves in part of their own projects and acquire a stake in another borrower's activity. If the project returns were perfectly correlated, nothing would be gained, of course, from this transaction. If project returns are imperfectly correlated, however, each member will be left with a safer, more diversified portfolio of projects, and the overall scope for moral hazard will have been reduced. From the lender's perspective, each borrower now owns a less risky portfolio of production and monitoring projects.

Returning to the original model, notice that the scope for making joint liability loans work depends on the assumed timing of the game in a rather crucial way. As is standard in most of the literature on monitored lending and hierarchical agency structures, I have assumed that the monitoring actions that the intermediary or group members take to modify (other) borrower's goals are chosen and set in place prior to the borrower's choice of diligence. Any threatened or implied sanctions that might form part of this monitoring strategy are hence assumed to be in place and credibly believed by the borrower to whom they are directed. The possibilities for peer-monitoring unravel under the alternative assumption that both monitoring and productive action strategies are chosen simultaneously:

Remark 2 *If the structure of the game is modified so that borrower-cum-monitors choose their monitoring and productive activity actions simultaneously rather than sequentially, then the scope for creating social collateral through peer-monitoring collapses.*

This result is helpful for understanding the strong negative result obtained by

Itoh (1991) that teamwork will only be optimal under the assumption that "the marginal disutility of monitoring effort is zero at zero monitoring." That group lending collapses when the game is simultaneous can be demonstrated by contradiction. For assume otherwise. Then a group contract does exist which implements the symmetric action pair. Since this is the assumed Nash equilibrium outcome, $(\overline{\pi}, c)$ must be a symmetric best response. But this cannot in fact be the case because borrower 1 will reason that his best response to $(\overline{\pi}, c)$ is in fact $(\overline{\pi}, 0)$: given that borrower two will choose diligence, borrower one can only gain by economizing on the costly monitoring activity c. Borrower two will then reason that his best response to borrower 1's $(\overline{\pi}, 0)$ is $(\underline{\pi}, 0)$, which in turn leads borrower one to change to $(\underline{\pi}, 0)$. Thus the only symmetric equilibrium action-monitoring strategy of the game is $(\underline{\pi}, 0)$.

This paper therefore shows a way out of Itoh's dilemma. This points to an important aspect of the design of group contracts. It is not enough simply to create a joint liability contract to induce peer monitoring; the contract must also rely on a particular timing sequence and requires commitment. Actual lending practices may be reflecting these facts. The scheduling of regular group meetings, the use of periodic interim evaluations and monitoring reports, contingent loan renewals over time and the practice of rotating loans amongst borrowers so that not all have a loan at the same time, etc., are all mechanisms that may help to make monitoring strategies credible and may also be aimed at reducing the possibility of collusion. This is an area that merits further investigation.

There are many directions that this analysis can be extended. Allowing the borrowers to operate variable investment scale projects, to choose continuous action choice sets or to operate production technologies with multiple project outcomes should not alter the main findings in a fundamental way; nor should making borrowers risk averse[18].

The problem would be complicated in more interesting ways by introducing a more general correlation structure in the production project returns across borrowers. Several complementary and offsetting forces would then likely come into play to determine the shape of the final optimal contract. On the one hand, one might want

[18] In work that was carried out independently of my earlier 1996 paper on group loans, Madajewicz (1997) studied a model similar to the one of this paper and extends some results to the case of risk averse agents, under somewhat restrictive assumptions about risk preferences.

the contract to encourage monitoring interaction among the members through joint liability contracts for the reasons analyzed here. The contract would make each borrower's reward an *increasing* function of the measured performance of other borrowers in the group. If, however, there is sufficient correlation in the production project outcomes across borrowers, then one might want the contract to work in the opposite direction. For the reasons identified in the relative performance evaluation (RPE) literature, one might want to make each borrower's reward a *decreasing* function of the other borrower's measured performance.

While these two effects will therefore typically be in conflict, in a somewhat more general setting a lender might be able to design a structure that involves elements of both types of contract. For example, the lender might group borrowers into small borrowing circles within which joint liability incentives are used to encourage peer-monitoring, while at the same time using relative performance evaluation across groups.

4 Conclusion

Much of the legal institutional infrastructure that is taken for granted in more affluent and developed areas of the world that helps to frame and enforce economic transactions is often either imperfectly established or entirely missing in poorer areas, developing countries, and economies in transition. In such circumstances, lenders will find it simply unprofitable to lend to small and poor borrowers without additional collateral guarantees, even when they are free to charge whatever interest rate they want to recover expenses. If the poor are to have a chance to build upon their energies and abilities rather than remain marginalized because of the misfortune of having too few liquid resources, then effective intermediary institutions and contract arrangements to build bridges between the poor and new credit and trade opportunities will be needed.

Joint liability lending appears to be one such innovative mechanism, not only because it builds upon existing information and enforcement methods in local communities but more fundamentally because it may potentially stimulate new monitoring and enforcement activities. While other analyses of group loans under moral hazard have relied upon an assumed information advantage or full side-contracting assumptions and costless monitoring, this paper has shown that an advantage to joint liability loans exists even under the more realistic assumption that borrowers cannot side-contract and monitoring is costly and subject to moral hazard. While group loans were shown to be sometimes optimal, the limits to group lending were also made apparent, and different types of financial contracts will be optimal for different types of borrowers.

Are joint liability contracts nothing more than a curious and specialized contract form that has proven useful only to a few microfinance organizations worldwide, and interesting primarily to economic theorists? This is a debate that ultimately needs to be settled empirically, using methods that test the theory. A case can be made that joint liability contracts are in fact ubiquitous in our society: a large part of all economic activity takes place within households, firms, partnerships, work teams, and other sorts of group which are organized at least in part by property relations that imply some form of profit sharing or joint liability (Holmstrom, 1999). Rather than just being narrowly compensated for their individually measured performance or contribution to a project, members share in the fortunes and misfortunes of the overall enterprise. There is much room for further research on these topics.

Appendix 1.

To show that the proposed contract s_{ij} is optimal requires that we show that it induces a symmetric subgame perfect Nash equilibrium (SPNE) where each borrower chooses the strategy profile $(c, \overline{\pi})$ and monitoring expense c is kept at a minimum.To do this we first characterize equilibria to the subgames $\zeta(\cdot, \cdot)$ and then argue why the contract induces each player to choose minimum monitoring intensity c in the first stage.

Figure 5 helps visualize the payoffs to different cells in the subgames $\zeta(\cdot, \cdot)$ discussed below. The figure is drawn for borrower 1 monitoring at intensity c. Borrower 1's payoff is then drawn on the vertical and borrower two's monitoring intensity is on the horizontal. Note that the structure of the optimal contract discussed in Proposition 1 requires $DD(c, c) \geq NN(0, 0) \geq NN(c, 0)$ where the first inequality follows from the no-collusion constraint (17) and the second inequality is obvious. Since $DD(c, c) = DD(c, 0)$, it follows that $DD(c, 0) \geq NN(c, 0)$. The figure is drawn for the case where this holds as a strict equality (point C).

Lemma 3 *: Under the proposed optimal contract $DD(c, c) - ND(c, c) > DN(c, c) - NN(c, c)$.*

Proof: Assume not. Then $DD(c, c) - ND(c, c) \leq DN(c, c) - NN(c, c)$. Substituting the optimal contract of the form $s_{ss} = Z(c)$ and $s_{ij} = -\underline{A}(c)$ for all other i, j and rearranging leads to the conclusion that $\overline{\pi}Z(c) \leq \underline{\pi}Z(c)$, a contradiction since by assumption $\overline{\pi} > \underline{\pi}$. ■

The fact that $DD(c, c) - ND(c, c) > DN(c, c) - NN(c, c)$ suggests that the player's actions in the subgame $\zeta(c, c)$ are *strategic complements*: player 1's marginal payoff to choosing diligence over non-diligence is increasing in player two's level of diligence, and vice-versa. The presence of strategic complementarities alerts us to the possibility of multiple, pareto ranked equilibria in this subgame (Cooper and John, 1988). As the following claim establishes, this is indeed the case.

Lemma 4 *: $(\overline{\pi}, \overline{\pi})$ and $(\underline{\pi}, \underline{\pi})$ are Pareto ranked Nash equilibria of subgame $\zeta(c, c)$, with $DD(c, c) > NN(c, c)$.*

Proof: $(\overline{\pi}, \overline{\pi})$ is a Nash equilibrium by construction since $DD(c,c) \geq ND(c,c)$ (recall 16). To see that $(\underline{\pi}, \underline{\pi})$ is also a Nash equilibrium requires that $NN(c,c) \geq DN(c,c)$. From the previous lemma the vertical distance $DD(c,c) - DN(c,c)$ is larger than the vertical distance $ND(c,c) - NN(c,c)$ (segment EG is larger than segment ED in the figure). Thus $NN(c,c')$ will intersect $DN(c,c')$ at some point $c^{**} > c$. This is indicated by point F in the figure. Thus $NN(c,c) > DN(c,c)$, and $\underline{\pi}$ is a best response to $\underline{\pi}$ and vice-versa.

That the equilibria are pareto ranked follows from the fact that $DD(c,c) \geq NN(0,0) > NN(c,0) \geq NN(c,c)$ where the first inequality follows from the no-collusion constraint, the second one is obvious because monitoring is a cost, and the last inequality follows because $B(0) \geq B(c')$ for all $c' \geq 0$. I assume that the borrowers coordinate on the higher equilibrium. ■

Lemma 5 *:* $(\underline{\pi}, \underline{\pi})$ *is the unique Nash equilibrium to subgames* $\zeta(0,c)$*,* $\zeta(c,0)$ *and* $\zeta(0,0)$.

Proof: Consider subgame $\zeta(0,c)$. From the figure it is evident that $(\overline{\pi}, \overline{\pi})$ cannot be a Nash equilibrium because $ND(c,0) \geq DD(c,0)$ so borrower one's best reaction to $\overline{\pi}$ is $\underline{\pi}$. However, borrower one chooses $\underline{\pi}$ as a best response to two's $\underline{\pi}$ because $NN(0,c) > DN(0,c)$. Since borrower two would do likewise $(\underline{\pi}, \underline{\pi})$ is the unique Nash equilibrium of the subgame. A symmetric line of reasoning establishes the result for $\zeta(0,c)$ and $\zeta(0,0)$. ■

Moving back in the game tree, since the equilibrium payoff $DD(c,c)$ to borrower one from subgame $\zeta(c,c)$ is higher than the equilibrium payoff $NN(0,c)$ from subgame $\zeta(0,c)$ it is evident that c is a best response to c at the first stage. It is just as easy to see that $(0,0)$ is also a Nash equilibrium of the game in monitoring intensities. The no-collusion constraint (17) requires, however, that payoffs to each borrower under (c,c) exceed those from $(0,0)$ to assume the two borrowers will not collude to choose the former equilibrium. Thus $\{(c, \overline{\pi}), (c, \overline{\pi})\}$ emerges as the chosen subgame perfect Nash equilibrium of the overall game.[19]

To see that the proposed solution minimizes on monitoring costs, note that the borrower's overall return $E(s_i|\overline{\pi}, \overline{\pi}) = E(x|\overline{\pi}) + \gamma I - c$ will be maximized when

[19] It is straightforward to show that the first-stage game in monitoring intensities also displays strategic complementarities, or that $DD(c,c) - NN(0,c) > NN(c,0) - NN(0,0)$.

monitoring intensity is at a minimum. The minimum monitoring intensity is obtained when the borrower uses all of his available collateral resources, at $A = A^g(c)$, which is the value used in the proposed optimal contract.

A last step is to check whether there are in fact any gains to monitoring within a group, in other words, whether the first dollar spent on monitoring reduces the collateral requirement or whether $\frac{dA^g(c)}{dc}|_{c=0} < 0$. This condition simplifies to $B_c(0) < -\frac{1}{\pi}$, the condition stated at the outset of Proposition. ■

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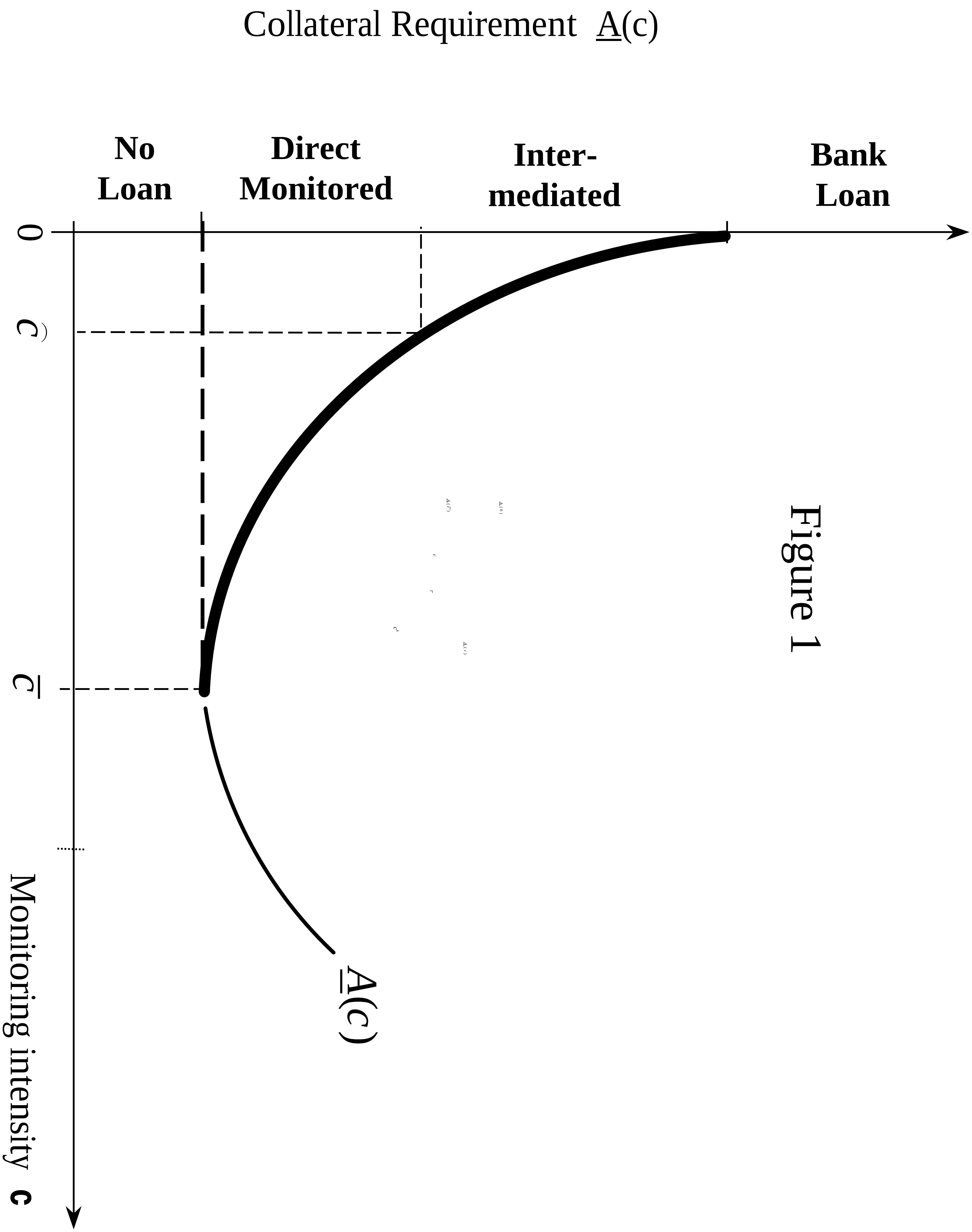
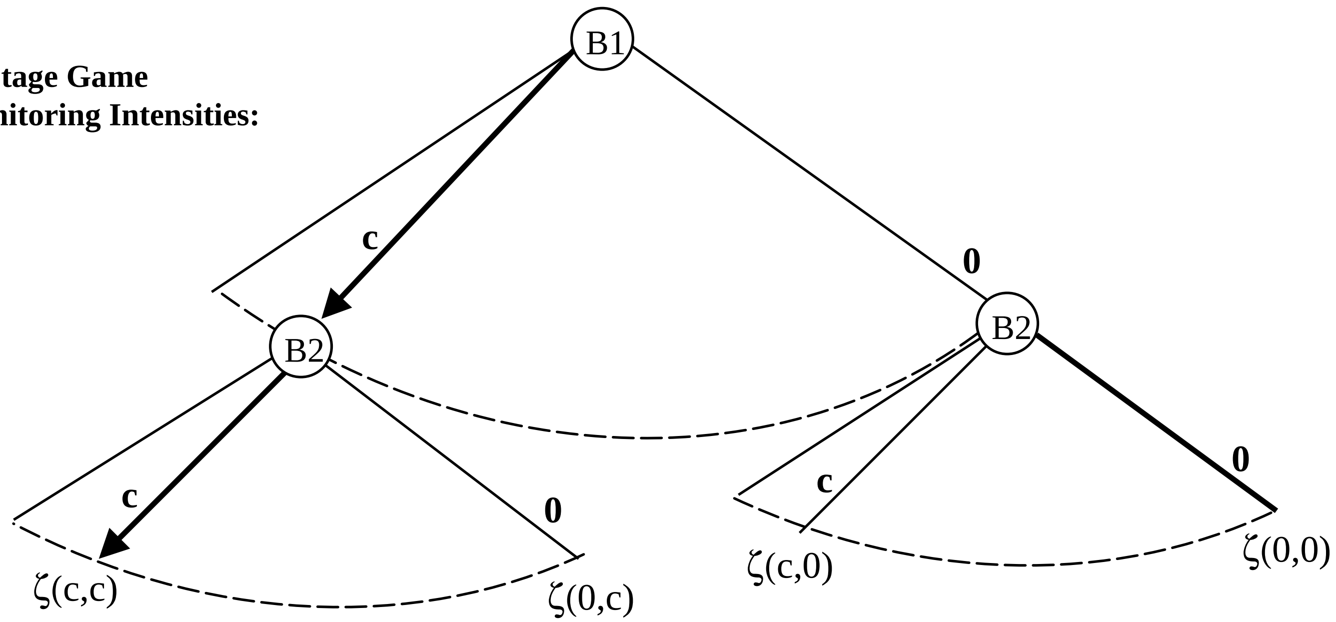


Collateral Requirement A(c)
No Loan
Direct Monitored
Inter-mediated
Bank Loan
0
c
c
A(c)
Monitoring intensity c

Figure 1

Figure 2

First Stage Game in Monitoring Intensities:



Subgames $\zeta(c^1,c^2)$:

$\zeta(c,c)$

	$\overline{\pi}$	$\underline{\pi}$
$\overline{\pi}$	*DD*(c, c)	*DN*(c, c)
$\underline{\pi}$	*ND*(c, c)	*NN*(c, c)

$\zeta(0,c)$

DD(0, c)	*DN*(0, c)
ND(0, c)	*NN*(0, c)

$\zeta(c,0)$

DD(c, 0)	*DN*(c, 0)
ND(c, 0)	*NN*(c, 0)

$\zeta(0,0)$

DD(0, 0)	*DN*(0, 0)
ND(0, 0)	*NN*(0, 0)

Figure 3

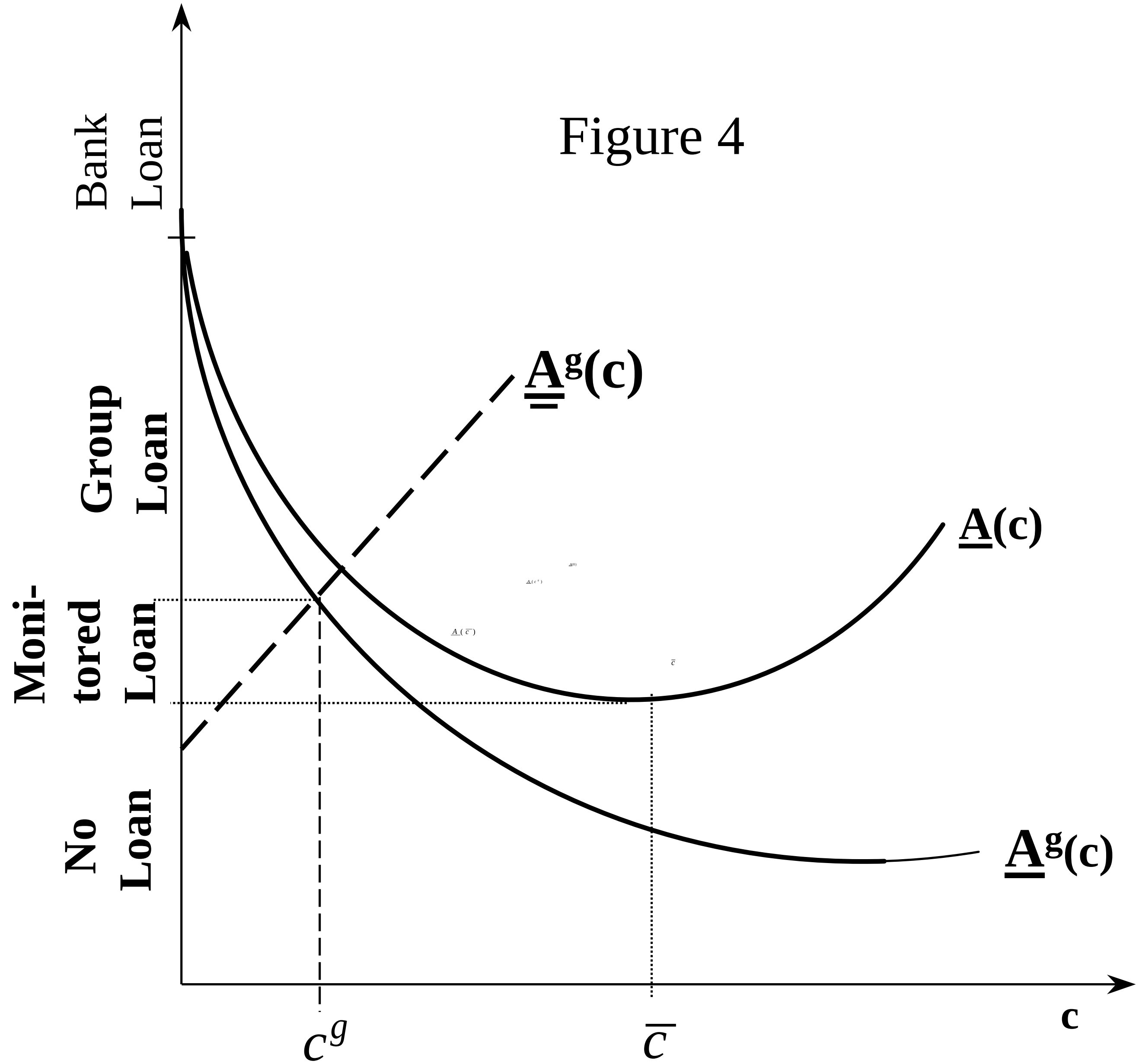
		Borrower Two $\overline{\pi}$	**Borrower Two** $\underline{\pi}$
Borrower One	$\overline{\pi}$	$E(s_{ij} \mid \overline{\pi}, \overline{\pi})$ $-c^1$	$E(s_{ij} \mid \overline{\pi}, \underline{\pi})$ $-c^1$
Borrower One	$\underline{\pi}$	$E(s_{ij} \mid \underline{\pi}, \overline{\pi})$ $+B(c^2) - c^1$	$E(s_{ij} \mid \underline{\pi}, \underline{\pi})$ $B(c^2) - c^1$

<u>or</u>

		Borrower Two $\overline{\pi}$	**Borrower Two** $\underline{\pi}$
Borrower One	$\overline{\pi}$	$DD(c^1,c^2)$	$DN(c^1 ,c^2)$
Borrower One	$\underline{\pi}$	$ND(c^1 ,c^2)$	$NN(c^1 ,c^2)$

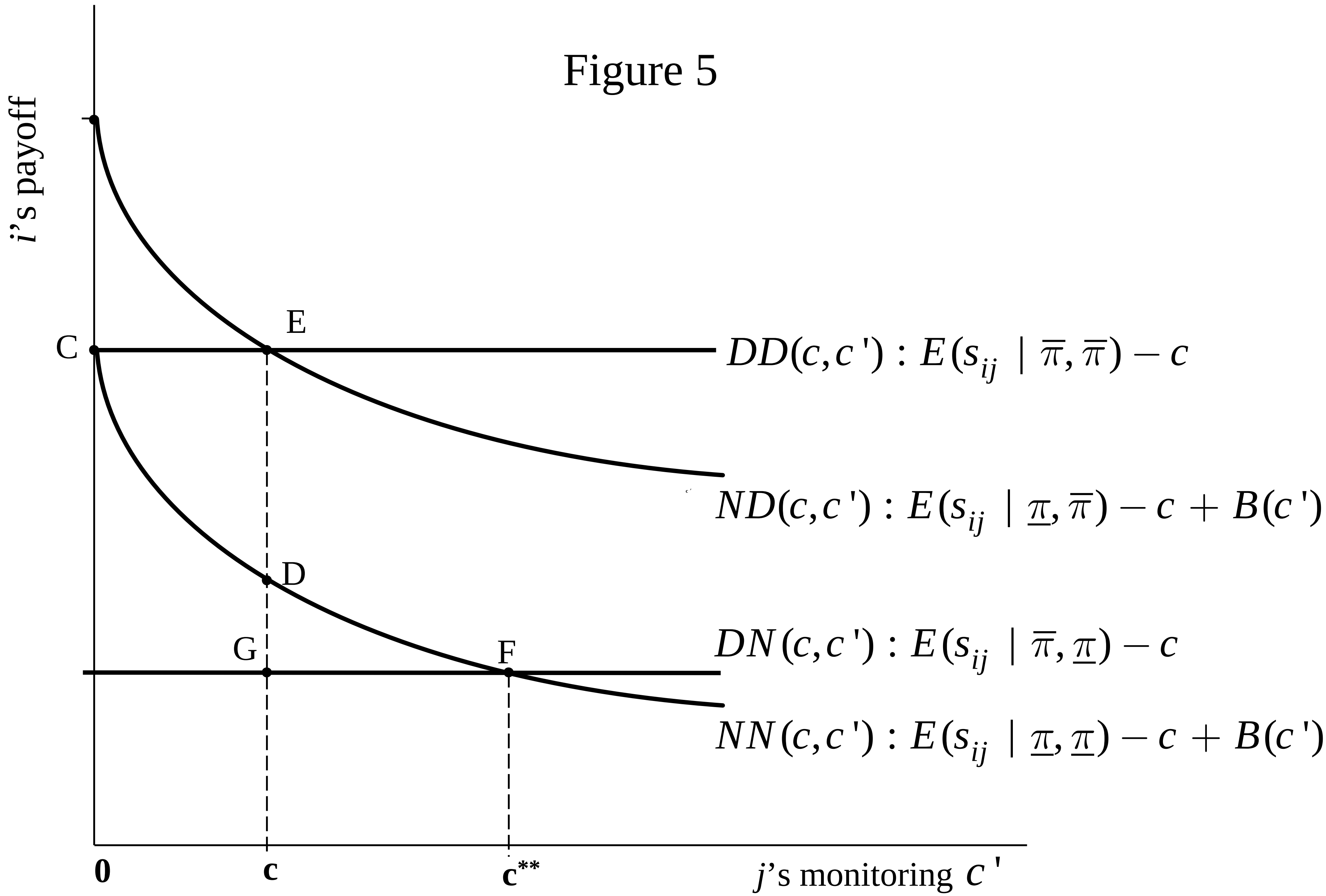
(only payoffs to
borrower one are shown)

Figure 4



Bank Loan
Group Loan
Moni-tored Loan
No Loan
$\underline{\underline{A}}^g(c)$
$\underline{A}(c)$
$\underline{A}^g(c)$
c^g
$\bar{c}$
c

Figure 5



i's payoff
C
E
D
G
F
DD(c,c') : E(s_ij | π̄, π̄) − c
ND(c,c') : E(s_ij | π̲, π̄) − c + B(c')
DN(c,c') : E(s_ij | π̄, π̲) − c
NN(c,c') : E(s_ij | π̲, π̲) − c + B(c')
0
c
c**
j's monitoring c'